STUDIES IN THE CARBOHYDRATE TOLERANCE OF NORMAL WOMEN

BY

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Lola Merle Cremeans

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I. INTRODUCTION

A. Definition.

In clinical practice sugar tolerance is defined as the largest number of grams of glucose which can be ingested at one time without causing glycosuria[1]. Allen[2] defines sugar tolerance as a convenient, though somewhat ill-chosen, expression to denote the upper limit of complete assimilation of sugar, the threshold dosage at which it barely begins to appear in the urine. Woodyatt[3] maintains that real tolerance should be regarded as a velocity and not as a weight, that is, it must be expressed as the number of grams of glucose per kilogram of body weight per hour of time which just fails to cause glycosuria. In experimental investigation carbohydrate tolerance has generally been considered as the number of grams of carbohydrate per kilogram of body weight which can be ingested during fasting without giving rise to a sufficient amount of sugar in the urine to give a positive copper reduction test.

Benedict[4] has recently pointed out that the copper reduction tests are of no value for concentrations of less than one tenth of one per cent, and that since sugar is normally present in the urine the use of the term glycosuria to imply a sudden point at which sugar seems to appear in the urine is inexact. He therefore

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1. Mendel, L., and Jones, Martha, J. Biol. Chem., 1920, 43, 492.
2. Allen, F.M., Glycosuria and Diabetes, 1913, 22.
3. Woodyatt, R.T., Sansum, W.D., and Wilder, R.M., J. Am. Med. Assoc., 1915, 65, 2067.
4. Benedict, S.R., Osterberg, E., and Neuwirth, I., J. Biol. Chem. 1918, 34, 258.

proposes the term "glycuresis" to indicate an increase above that of the control and regards carbohydrate tolerance as the number of grams of carbohydrate per kilogram of body weight which can be ingested during fasting without causing an increase in the absolute amount of reducing sugar in the urine.

B. Importance of Tolerance Tests.

The estimation of carbohydrate tolerance is not only of academic interest but also of clinical value. Barringer and Roper[1] traced cases of spontaneous glycosuria and found that at the end of five years, twenty per cent of a group of spontaneous glycosurics had become diabetic; fifteen per cent had become suspicious cases; ten per cent were somewhat suspicious; fifty-five per cent had remained free from diabetes. They conclude that the determination of alimentary glycosuria arising from the ingestion of glucose or cane sugar, provided that the test is properly conducted and repeated at intervals, affords a valuable aid to prognosis in cases of spontaneous glycosuria.

Carbohydrate tolerance tests are especially valuable in diagnosing diabetes. Naunyn[2] defines diabetes on a tolerance basis, emphasizing the fact that any man will excrete sugar if he take a sufficiently large amount of glucose, but only a diabetic subject will exhibit glycosuria after any amount of starch which it is possible to administer.

In many diseases, such as acute fevers and diseases of the nervous system, there is a lowered tolerance. The carbohydrate

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1. Barringer, T. B., and Roper, J. C., Am. J. Med. Sci., 1907, 133, 848.
2. Garrod, A.E., 1913 II, Brit. Med. J., 850.

tolerance test is used as routine procedure for a number of diseases. However, Friedman and Strouse[1] state that it can never be used as a specific test for disease because many organs play a role in the metabolism of carbohydrates.

C. Factors Influencing Tolerance.

Sugar tolerance varies not only with different individuals but the same individual may show a difference in tolerance at different times. There are so many factors which must be considered that it is hard to establish any standard.

1. Muscular Exercise.

Muscular exercise seems to increase the tolerance for sugar. Grober[2] and Stütz[3] reported an increase in sugar tolerance in man by muscular exercise. Comessatti's[4] rabbits, working in a tread-mill, were able to use twenty per cent more dextrose than they could normally without glycosuria. Hohlweg[5], by exercise, made a dog assimilate excessive amounts of galactose, maltose, and saccharose, but lactose continued to be excreted quantitatively.

2. Temperature.

A rise in the body temperature has been found to increase the tolerance for glucose. Grober and Stütz, mentioned above, found that an elevation of temperature raised the limit of assimilation in man. The work of Hohlweg and Voit[6] showed a

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1. Friedman, J.C., and Strouse, S., Arch. Int. Med., 1914, 14, 531.
2. Grober, J., Dtsch. Arch. f. klin. Med., 95, 1908, 137.
3. Stütz, L., Inaug. Diss. Jena, 1908.
4. Comessatti, G., Hofmeister's Beiträge, 1906-7, 9, 67.
5. Hohlweg, H., Ztschr. f. Biol., 1911, 55, 396-408.
6. Hohlweg, H., and Voit, F., Ztschr. f. Biol. 1908, 51, 491-510.

similar effect in the rabbit.

3. Sex.

Allen[1] stated that sex is without influence. In work not yet published, Croll[2] found that men and women did not differ greatly in carbohydrate tolerance.

4. Age.

Age has a decided influence upon tolerance. Quite frequently we find older people with lower tolerance. Aldor[3] found a slight reduction of sugar tolerance in aged human beings. However, mere senility is not the only factor, since with age other complications may arise which may interfere with sugar assimilation.

5. Pregnancy.

Carbohydrate tolerance is lower during pregnancy. Jaeger[4] reported that when dextrose was added to the diet of pregnant women, there was a certain decrease in the limit of tolerance for that sugar. A decrease in the power of assimilation of levulose was also observed. Reichenstein[5] found that glycosuria frequently occurred in pregnant women after the ingestion of one hundred grams of dextrose.

6. Inanition.

Dogs reduced to actual inanition have a very low

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1. Allen, F. M., Glycosuria and Diabetes, 34.
2. Croll, Hilda, A study of Sugar Tolerance in Women, 1917, Master's Thesis, University of Illinois.
3. Allen, F. M., Glycosuria and Diabetes, 34.
4. Jaeger, F., Z. Geb. Gyn., 74, 586-99. Chem. Abs. 1914, 8, 143.
5. Reichenstein, M., Wien. klin, Wchnschr., 1909, 1445.

dextrose tolerance, as shown by Hofmeister[1] and Allen[2]. "Vagabond glycosuria" observed in tramps is due to malnutrition, weakness, and starvation.

D. Classification of Glycosurias.

There are many varieties of glycosurias and many causes. Barringer and Roper[3] name two types of glycosuria, (a) continuous (diabetic) and (b) transient (non-diabetic). Alimentary glycosuria, which may be either continuous or transient, when arising from intake of any sugar, is termed e saccharo; when from starch, ex amylo (invariably diabetic); and when from a mixed diet, spontaneous. Of all the classifications of glycosurias that of Allen[4] (see table I) is perhaps the best and most instructive.

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1. Hofmeister, F., Arch. exp. Path. u. Phar., 1889-90, 26, 355.
2. Allen, F. M., Glycosuria and Diabetes, 580.
3. Barringer, T. B., and Roper, J. C., Am. J. Med. Sci., 1907, 132,842.
4. Allen, F. M., Glycosuria and Diabetes, 530.

TABLE I

Causes of Glycosuria (Allen)

1. Alimentary

   A. Normal--Due to over-doses of sugar orally, subcutaneously, intravenously, etc.

   B. Pathological

      I. Due to general malnutrition

         a. Hunger glycosuria of dogs

         b. Vagabond glycosuria

         c. "Dyspeptic" glycosuria

         d. Cachetic glycosurias

      II. Due to any of the causes of spontaneous glycosuria.

2. Spontaneous

   A. Pancreas

      (Organic disease) Diabetes mellitus
      (Functional disease)

   B. Liver

      I. Hemorrhage

      II. Injections into portal vein

      III. Poisons

         a. Drugs

         b. Animal products (?)

         c. Pregnancy(?)

      IV. Infections (?)

      V. Asphyxia(?)

      VI. Traumata

   C. Kidney

      I. Glycosuria due to increased permeability to blood sugar

a. Diuretics(?)

b. Specific renal poisons (cantharidin, metallic salts, etc.)

c. Sera and organ extracts

d. Renal injuries

e. Clinical renal glycosuria

II. Glycosuria due to breaking up of abnormal compounds

a. Phloridzin

b. Glycogen, dextrin, starch (and in dogs cane-sugar) (?)

D. Nervous System

I. Central

a. Piqûre, experimental brain lesions, clinical brain troubles

b. Emotions

c. Asphyxia (including asphyxial drugs)

d. Nerve-poisons

e. Salt injections

f. Irritation of afferent nerves

g. Cold

h. Fever

i. Infections

j. Fatigue(?)

II. Peripheral

a. Stimulation

b. Adrenalin

c. Drugs and poisons(?)

III. Undetermined

Thyroid

Parathyroid

Hypophysis

Ligature of thoracic duct (and clinical chyluria(?))

Pregnancy(?)

Tumors(?)

Adolescence(?)

Gout(?)

II. REVIEW OF LITERATURE

A. Sugar in Normal Urine.

Since normal urine does not ordinarily reduce Fehling's solution, it is frequently spoken of as being sugar free. Crismer[1], however, in 1888, spoke of dextrose as a normal constituent of urine. In 1890, Moritz[2] carried out experiments on the normal copper reducing constituents of urine and proved that glucose was present. Roos[3] (1891), Salkowski[4] (1892), and Pavy[5] (1894) showed that an osazone could be obtained from normal urine. Investigations of Baisch[6], in 1895, proved the regular occurrence of carbohydrate in normal urine which resulted in the isolation of what he believed to be isomaltose. Breul[7], in 1898, made quantitative sugar determinations on normal urine and found that the normal sugar excretion was between 0.36 and 1.95 grams per day, which was from 0.027 to

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1. Crismer, L., Ann. Soc. Méd.-Chir. de Liége, 1888, Oct.
2. Moritz, F., Deutsch. Arch. klin. med., 1890, 46, 217.
3. Roos, Ztschr. f. physiol. Chem., 1891, 15, 523.
4. Salkowski, Ibid. 1892, 17, 220.
5. Pavy, F.W., Physiology of the Carbohydrates, 1894.
6. Baisch, K., Z. Physiol. Chem., 1895, 20, 248.
7. Bruel, L., Arch. exp. Path. u. Pharm., 1898, 40, 1.

0.178 per cent of the urine. The usual per cent was from 0.05 to 0.06. Lemaire[1] repeated and confirmed Baisch's work. Pavy and Siau[2] identified isomaltose in urine, blood, and tissue and concluded that dextrose is not the only reducing sugar in the body. Schöndorff[3], in 1907, found that normal human urine contains sugar in measurable quantity, ordinarily from 0.0105 to 0.0274 per cent. In 1911, Oppler[4] criticized the existing methods for determining small traces of dextrose in blood and urine. With a new and more accurate procedure, he found a fermentable, optically inactive reducing sugar in a concentration of about 0.04 per cent of the urine. The true dextrose was probably less than 0.01 per cent and in one case it was less than 0.001 per cent. In 1918, Benedict, Osterberg and Neuwirth[5], using a new colorimetric method, made quantitative urinary sugar analyses on two normal men. On an ordinary mixed diet the twenty-four hour elimination averaged one gram for the one and between 608 and 697 milligrams for the other. Recently Shaffer and Hartmann[6] devised a new method by which they found the reducing substance in normal urine to be 0.02 or 0.03 per cent. Sumner[7] also reported sugar in normal urine.

B. Carbohydrate Tolerance.

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1. Lemaire, Ztschr. f. physiol. chem., 1899, 21, 450.
2. Pavy, F.W., and Siau, R.L., J. Physiol., 1901, 282-290.
3. Schöndorff, B., Arch. ges. Physiol., 1907, 121, 572.
4. Oppler, B., Z. Physiol. Chem., 1911, 75, 71.
5. Benedict, S.R., Osterberg, Emil, and Neuwirth, I., J. Biol. Chem., 1918, 34, 217-262.
6. Shaffer, P.A., and Hartmann, A.F., J. Biol. Chem.,1921,45,365-90.
7. Sumner, J.B., J. Biol. Chem., 1921, 46, Proc. xxi.

1. Glucose Tolerance.

Moritz[1], in 1891, found two grams of glucose in the urine of a man after the ingestion of two hundred grams of glucose. Strauss[2] did experiments on fifty subjects and produced slight glycosuria in but four, by feeding one hundred grams of anhydrous glucose in five hundred cubic centimeters of water. On repetition, even these four were negative. Jacobsen[3] fed each of fourteen normal persons one hundred grams of glucose. Six whose blood sugar did not rise above 0.16 per cent had no sugar in the urine; eight whose blood sugar went above 0.17 per cent did have glycosuria. Von Noorden[4] asserted that the assimilation limit for glucose varies from one hundred fifty to two hundred grams. Rankin[5] stated that the limit of tolerance for the average person is about one hundred fifty grams of glucose. In a review of literature, Porter and Dunn[6] found that for adults the amount of pure dextrose that would not exceed the limit of tolerance was usually from one hundred to two hundred fifty grams, that the single maximum quantity by mouth was from two to four grams per kilogram of body weight, and that the maximum subcutaneous injection was from one to one and one half grams per kilogram. Woodyatt, Sansum and Wilder[7], found that

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1. Moritz, F., Verhandlungen des 10ten Congresses f. inn. Med. 1891, 492.
2. Strauss, H., Deut. Med. Woch., 1897, Nos. 18 and 20.
3. Jacobsen, Biochem. Ztschr., 1913, 56, 471.
4. Von Noorden, C., Disorders of Metabolism and Nutrition, Eng. Trans., 1905, 33.
5. Rankin, G., Brit. Med. J., 1913, I, 59, 594.
6. Porter and Dunn, Am. J. Dis. Child, 1915, 10, 79.
7. Woodyatt, Sansum and Wilder, J. Am. Med. Ass., 1915, 65, 2068.

with intravenous injections of glucose the normal tolerance limit was close to 0.85 grams of glucose per kilogram of body weight per hour. Wilder[1] confirmed this work in 1917. Bailey[2] reported a lower tolerance than those mentioned above. In a fasting normal person he obtained a glycosuria following the ingestion of seventy-five grams of glucose in four hundred cubic centimeters of weak tea. Using the Myers method, he found nine tenths per cent of sugar in the urine at the end of about one hour. In direct contrast are the results of Taylor and Hulton[3], who found that glycosuria did not occur following the largest possible ingestions of pure glucose and concluded that there is apparently no limit of assimilation. In their experiments, healthy students were given a light breakfast and in two and one half to three hours this was followed by the ingestion of pure glucose in two hundred, three hundred, and four hundred gram quantities. The urinary test was essentially by Benedict's qualitative method. Nearly all of the subjects tolerated two hundred grams. Of the nine who took three hundred grams three had glycosuria; of the six who took four hundred grams two had glycosuria. The fact that so few exceeded their tolerance may be explained by the fact that the tests were made upon the twenty-four hour urinary specimen. More valuable data would have been obtained if hourly urinary analyses had been made, since in that way the progress of the

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1. Wilder, R.M., Arch. Int. Med., 1917, 19, 311.
2. Bailey, C.V., Proc. Soc. Exp. Biol. Med., 13, 154, 1915-16.
3. Taylor, A.E., and Hulton, Florence, J. Biol. Chem., 1916, 25, 173-175.

glycosuria can be followed. Hamman and Hirschman[1] administered one hundred grams of glucose in three hundred cubic centimeters of lemonade in the morning after the night fast. Two cases out of six showed glycosuria. Field[2] fed normal colored males one hundred grams of pure glucose on an empty stomach. No case ever showed the slightest trace of reducing sugar in the urine. Benedict, Osterberg, and Neuwirth[3], using a quantitative colorimetric method[4], found that in one man twenty grams of dextrose on an empty stomach showed an effect; whereas, in the other one the first effect was shown after ingestion of sixty grams of dextrose. Their experience has led them to regard fifty grams of glucose as about the upper limit of absolute tolerance in normal human adults. Goto and Kuno[5] used the same method for determining the glucose tolerance of normal Japanese. One hundred grams of glucose dissolved in one hundred fifty cubic centimeters of water were ingested in the morning after a night fast. Since the weights ranged from forty-two to sixty-three kilograms, the amounts used were from 1.6 to 2.3 grams per kilogram. Thirty-three out of fifty-three adults excreted sugar. The quantities were small,--0.25 grams to 0.795 grams in four hours.

2. Sucrose Tolerance.

In 1884, Worm-Müller[6] found in one case glucose in the

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1. Hamman, L and Hirschman, I., Arch. Int. Med., 1917, 20, 761.
2. Field, C., Proc. Soc. Exp. Biol. Med., 1919, 17, 29.
3. Benedict, S.R., Osterberg, E., and Neuwirth, I., J. Biol. Chem., 1918, 34, 257.
4. Benedict, S.R., and Osterberg, E., J.Biol.Chem., 1918, 34, 195.
5. Goto, K., and Kuno, U., Arch. Int. Med., 1921, 27, 224.
6. Worm-Müller, Pflüger's Arch. f. Physiol.,1884,Band xxiv, 576.

urine after the ingestion of fifty grams of cane sugar. Moritz[1] stated that he always found glucose in the urine after large quantities of cane sugar were taken on an empty stomach. Linossier and Roque[2] found five cases of glucose in the urine after the ingestion of fifty grams of cane sugar. Barringer and Roper[3] found that the ingestion of one hundred grams of cane sugar on an empty stomach did not produce more than mere traces of glucose in the urine of normal healthy men students. Le Goff[4] reported experiments with twenty-two subjects, in which all but two cases showed saccharosuria following the ingestion of one hundred grams of saccharose. Field[5] obtained no glycosuria after the ingestion of one hundred grams of sucrose.

3. Tolerance for Other Carbohydrates.

Experiments with other carbohydrates have not been so numerous. The order of the ease with which the sugars give rise to mellituria is easily seen in table II, quoted by Allen[6] from Linossier and Roque.

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1. Moritz, F., Verhandl. X Congress f. inn. Med. 1895, 125.
2. Linossier and Roque, Arch. de Med. exper, et d'anat. pathol. 1895, 7, 228-53.
3. Barringer, T.B., and Roper, J.C., Am.J.Med.Sci., 1907, 133, 842-855.
4. Le Goff, J., Compt. Rend., 1911, 152, 1785.
5. Field, C., Proc. Soc. Exp. Biol. Med., 1919, 17, 29.
6. Allen, F.M., Glycosuria and Diabetes, 1913, 74-75.

TABLE II.

Order of Ease with which Sugars Give Rise to Mellituria (Allen)

Hofmeister (dog)	Worm-Müller (man)	Moritz (man)	Linossier and Roque (man)
galactose	glucose	lactose	saccharose
lactose	saccharose	saccharose	glucose
glucose	lactose	glucose	lactose
levulose	levulose		
saccharose			

He also gives the data, found in table III, from Von Noorden showing the amount of carbohydrate which causes sugar to appear in the urine after ingestion.

TABLE III.

Amount of Carbohydrate which Causes Sugar to Appear in Urine(Allen)

Galactose	about 20 g.
Lactose	more than 120 g.
Levulose	120-150 g.
Dextrose	150-180 g.
Saccharose	150-200 g.

Mendel and Jones[1] found that the tolerance in rabbits occurred in the order of increasing assimilability as follows: sucrose, levulose, glucose, maltose, and dextrin.

C. Influence of Food on Sugar Excretion.

Miura[2], Japanese investigator, found negative results after

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1. Mendel, L., and Jones, Martha, J. Bio. Chem., 1920, 43, 195.
2. Miura, K., Ztschr. f. Biol., 1895, 32, 281-303.

the largest meal of rice he could ingest. Breul[1] could not increase the output appreciably by heavy carbohydrate feeding prolonged for eight days. Barantschik[2] reported practically no effect on the normal trace of sugar in the urine after complete withdrawal of carbohydrate for five days. Schöndorff's[3] investigations showed that excessive carbohydrate might increase the urinary sugar from 0.0105 and 0.0274 per cent to 0.1 per cent. The results of Benedict, Osterberg and Neuwirth[4] showed an alimentary glycuresis even when the diet was sugar free. A high protein (carbohydrate-poor) diet showed a marked drop in total elimination and a high carbohydrate diet caused a rise.

D. Methods of Urinary Sugar Determinations.

Within the last few years a number of methods for the determination of small amounts of sugar in urine have been proposed. Myers'[5] method consists of the precipitation of the interfering substances with picric acid and the determination of the urinary sugar by the reduction of picric acid to picramic acid in alkaline (sodium carbonate) solution. The color is compared in a colorimeter with a glucose or a picramic acid standard. This method has been criticised[6] as giving too high results; they have been found to be even one hundred per cent too high in some cases. Attention has

---

1. Breul, L., Arch. exp. Path. u. Phar., 1898, 40, 1.
2. Barantschik, Russk. Wratsch., 1911, No. 2.
3. Schöndorff, B., Arch. ges. Physiol., 1907, 121, 572.
4. Benedict, S.R., Osterberg, E., and Neuwirth, I., J. Biol. Chem., 1918, 34, 246.
5. Myers, V.C., Proc. Soc. Exp. Biol. Med., 1915-16, 13, 178-180.
6. Benedict, S.R., and Osterberg, E., J. Biol. Chem., 1918, 34, 195.

been called to the fact that the creatinine, which is not removed, yields about five times as much color with picric acid as does an equal weight of glucose.

Folin and McEllroy[1] published a method in 1918 which is a titration of copper sulphate solution with the urine in the presence of a phosphate, carbonate, and sulfocyanate salt mixture. Haskins later modified the method by reducing the amount of sodium thiocyanate. Folin and Peck[2] further modified the method by varying the salt mixture to eliminate the unimportant but disconcerting loss of copper.

Of these later methods, the colorimetric one devised by Benedict and Osterberg[3] is of particular interest. It consists of a preliminary precipitation of interfering substances with mercuric nitrate in slight excess of sodium bicarbonate and the determination of sugar in the filtrate by the reduction of picric acid in alkaline (sodium carbonate) solution and a comparison of the resulting color with a standard. The precipitation with mercuric nitrate removes creatinine, total nitrogen, glycuronic acid, and polysaccharides. The advantages of this method are that : (1) it gives accurate results, (2) it requires a very small amount of urine, (3) very small amounts of sugar can be detected, (4) and the determination requires a relatively short time. The method has

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1. Folin, O., and McEllroy, W.S., J. Biol. Chem. 1918, 33, 513.
2. Folin, O., and Peck, E.E., 1919, 38, 287-291.
3. Benedict, S. R., and Osterberg, E., J. Biol. Chem., 1918, 34, 195-201.

been used by Kast, Wardell and Myers[1], Greenthal[2], and Goto and Kuno[3].

Shaffer and Hartmann[4] believe that the procedure of precipitation of urine with mercuric nitrate and sodium bicarbonate as used by Benedict and Osterberg is an almost ideal preparation for glucose determination, since it removes nearly all the interfering substances and does not precipitate, absorb, or destroy the glucose. They propose a new method in which the reversible reaction $Cu^{++} + I^{-} \leftrightarrows Cu^{+} + I_2$ is applied to the determination of the mixtures of cuprous and residual cupric copper resulting from the action of reducing sugar upon alkaline copper solutions. By iodometric titration either the cupric or the cuprous copper in a mixture of the two forms is determined. The glucose is calculated from a table showing the amount of copper reduced corresponding to known amounts of glucose. This delicate iodometric procedure seems to be admirably suited to the determination of small amounts of sugar.

Sumner[5] suggests a new reagent, 4-6- dinitroguaiacol, for the colorimetric estimation of sugar in normal and diabetic urine. Its advantage lies in the fact that dinitroguaiacol is reduced by no other urinary constituent than reducing sugar. Uric acid and

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1. Kast, L., Wardell, Emma, and Myers, V.C., Am. J. Med. Sci., 1920, 160, 877.
2. Greenthal, R.M., Am. J. Dis. Child., 1920, 20, 556-61.
3. Goto, K., and Kuno, N., Arch. Int. Med. 1921, 27, 224-237.
4. Shaffer, P.A., and Hartman, A.F., J. Biol. Chem., 1921, 45, 365-90.
5. Sumner, J.B., J. Biol. Chem., 1921, 46, Proc. xxi.

possibly phenols cause some increase in color but they are removed by norite.

E. Summary of Literature.

The results of the investigation of the literature may be summarized as follows:

Normal urine contains small amounts of reducing sugar; the quantity varies with the individual.

Practically all the tolerance tests have been done on men.

There is as yet no agreement as to the limits of tolerance for the various sugars. This diversity of opinion is due to lack of standardization in method of administration of sugar, in inaccurate urinary sugar methods, and in inadequate control of experiments.

There is also lack of agreement as to the effect of food on sugar excretion.

III. NEW EXPERIMENTS.

A. Object.

The object of the present work may be stated as follows: (a) to study the glucose tolerance of fasting normal women by means of the qualitative examination of the hourly urinary specimens and by the quantitative estimation of sugar in the same urines; (b) to study in the same manner the effect of the ingestion of food upon glucose tolerance; (c) to compare in the same way the hourly urinary sugar elimination for a day on an ordinary mixed diet with that on a high carbohydrate diet; (d) to determine the total daily excretion of sugar on an ordinary mixed diet.

B. Procedure.

1. Subjects.

Ten healthy normal young women, weighing from fifty to

sixty kilograms, were selected as subjects for the experiment. With the exception of two the ages were from twenty-one to twenty-three years old. The other two were twenty-seven and thirty-four years of age. Nine were students and one was an instructor. They were engaged in regular university occupations, studying, attending classes, or doing laboratory work. In only one case, O. R., did the family history show any diabetes, and even in this case none of her immediate family had been known to have the disease. All had had a sufficient training in home economics and chemistry to understand the details of the experiment and so to cooperate intelligently.

2. General Plan.

a. Glucose Tolerance.

In order that the exact tolerance for glucose might be obtained a specimen representing the urinary elimination for a fasting period of one hour was collected. Commercial glucose in varying quantities based on the body weight was ingested immediately. The hourly urines were collected and examined both qualitatively and quantitatively. It was convenient to start the experiment at 7:00 A. M., at which time the bladder was emptied and the urine was discarded. One hour later the bladder was again emptied--this sample was taken as a fasting specimen. Immediately the glucose, in sufficient weak tea* to make three hundred cubic centimeters, was ingested. The tea was given hot so as not to be so nauseating. The quantity of glucose used the first time was one and one half grams per kilogram of body weight and the amount was

*In one case, L. B., the glucose was given in water because of the particular diuretic effect of tea.

increased one half gram per kilogram of body weight each time. The experiment was not repeated in less than one week in order not to impair the tolerance. The urine was collected hourly for four hours after the ingestion of the glucose. Analyses were made within a short time. No water was ingested during the morning except in rare cases when the subject found difficulty in urination.

b. Influence of Food on Glucose Tolerance.

In order to determine the influence of ingested food, glucose was administered with a breakfast. In choosing the breakfast, the following factors were considered: ease of preparation, ease of measurement without weighing, and the typical American breakfast. It consisted of the following foods:

Orange	One medium
Egg (hard boiled)	One
Toast	Two medium slices
Butter	Two Tbsp.
Water (omitted when tea was ingested)	One glass

The breakfast was first ingested and the hourly sugar excretion was determined. The same plan and schedule was followed as given above except that the glucose was replaced by the breakfast. Then on another day the breakfast was ingested with tea containing two grams of glucose per kilogram of body weight and hourly determinations were made in the usual manner. In the case of O. R. whose tolerance was found to be less than one and one half grams of glucose per kilogram of body weight, the amount of glucose was reduced to one and one half grams per kilogram of body weight. Neither food nor water was ingested during the morning.

c. Effect of Diet on Hourly Sugar Excretion.

The course of alimentary glycuresis was followed through the day by examining the hourly urinary specimens in the same way. The experiment was begun at 7:00 A. M. with the same procedure as in former experiments. Breakfast was at 7:30 A. M., lunch at 12:15 P. M. and dinner at 6:15 P. M. The diet was just the ordinary mixed diet served at the boarding clubs. A record of the day's food was kept. The urine was collected hourly until 11:00 P. M. The night urine was collected at seven o'clock the next morning so as to obtain the complete twenty-four hour output. No food was eaten except at meals and the water intake was restricted. The specimens were kept cool and preserved with toluene. The morning and afternoon urines were analyzed on the first day and the night urines were analyzed on the following morning. The same schedule and procedure was followed with the carbohydrate-rich diet. Excessive amounts of carbohydrate were added to the diet.

d. Total Daily Sugar Excretion.

Data obtained in (c) were used for determining the total daily elimination of sugar on an ordinary mixed diet.

3. Method of Analysis.

In all the experiments the laboratory procedure was essentially the same. The volume of the urine was first measured and then the analyses followed. Benedict's[1] qualitative test was made on each sample of urine. The test is as follows: To five cubic centimeters of the reagent, add eight drops of urine, mix,

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1. Benedict, S.R., J. Am. Med. Ass., 1911, 57 II, 1193-94.

place in a boiling water bath for five minutes, remove, and allow to cool spontaneously. A greenish yellow, yellow, or reddish precipitate is a positive test for sugar. The reagent was made up in one liter quantities as follows: With heat dissolve 173 grams of sodium citrate and one hundred grams of sodium carbonate in about six hundred cubic centimeters of water. Pour the solution through a filter into a graduated cylinder and make it up to 850 cubic centimeters. Dissolve 17.3 grams of copper sulfate in one hundred cubic centimeters of water and make the solution up to 150 cubic centimeters. Pour the first solution into a large beaker or precipitating jar and add the copper sulfate solution slowly with constant stirring. The mixed solution is ready for use and does not deteriorate on standing.

The colorimetric method of Benedict and Osterberg[1] was used for the quantitative determinations. The only modification was the use of ten cubic centimeters of urine instead of fifteen or twenty cubic centimeters as suggested because the volumes were frequently less than twenty cubic centimeters and the use of ten cubic centimeters gave a sufficient amount of filtrate.

The reagents were prepared exactly according to the directions given by Benedict and Osterberg. The detailed account follows:

Mercuric nitrate solution--To 160 cubic centimeters of concentrated nitric acid in a beaker, add in small portions, 220 grams of mercuric oxide. When all is dissolved heat the mixture to boiling, cool, and add sixty cubic centimeters of five per cent sodium hydroxide solution. Make the solution up to one liter and

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1. Benedict, S.R., and Osterberg, E., J.Biol.Chem., 1918, 34, 195-201.

filter. Keep in a brown bottle.

Picrate-Picric Acid Solution. To five hundred cubic centimeters of one per cent sodium hydroxide solution in a liter flask or stoppered cylinder, add thirty-six grams of picric acid and about four hundred cubic centimeters of hot water. Shake the mixture occasionally until the picric acid is dissolved, cool, and dilute to one liter. The final solution is fully saturated with picric acid. A slight crystallization of picric acid on standing is of no account but if abundant crystallization occurs, due to the solution becoming too cold for some hours, it is desirable to redissolve the picric acid by warming before using.

The errors that may arise from the use of impure picric acid have been pointed out by Folin and Doisy[1]. In order to eliminate this source of error, Baker's Analyzed Picric Acid, was subjected to the purification process of Folin and Doisy. The procedure is as follows:

Transfer about six hundred grams of wet picric acid or about a pound of dry picric acid to a large beaker (capacity not less than four liters). Pour on boiling water until the beaker is nearly full and add two hundred cubic centimeters of saturated (fifty per cent) sodium hydroxide solution. Stir the solution and if necessary heat it again until all the picric acid has dissolved, yielding a deep red picrate solution. To the hot solution add rather slowly, with stirring, two hundred grams of sodium chloride. Cool the solution in running water to about thirty degrees Centigrade with occasional stirring. Filter on a large Buchner

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1. Folin, O., and Doisy, E.A., J. Biol. Chem., 1916-17, 28, 349.

funnel and wash the precipitate a few times with five per cent sodium chloride solution. Transfer the picrate to the large beaker, fill the latter with boiling water, and when the picrate is dissolved add, with stirring, first fifty cubic centimeters of ten per cent sodium hydroxide solution, and then one hundred grams of sodium chloride. Cool the mixture to thirty degrees Centigrade with stirring, filter, and wash the precipitate with sodium chloride solution as before. Repeat the solution and precipitation of the sodium picrate twice more, but for the last washing of the last precipitated picrate use distilled water instead of sodium chloride solution.

Dissolve the purified picrate in the same large beaker, with boiling distilled water and filter it hot on a large folded filter, collecting the filtrate in a large flask. To the hot filtrate add one hundred cubic centimeters of concentrated sulfuric acid, previously diluted with about two volumes of water. The liberated picric acid begins to come out at once. Put a beaker over the mouth of the flask and cool the latter under running tap water to about thirty degrees Centigrade. Filter with suction as before and wash the precipitate free from sulfates with distilled water. Dry the picric acid in an oven at a temperature of sixty degrees Centigrade.

The procedure for the sugar estimation is as follows: Measure ten cubic centimeters of urine into a six hundred cubic centimeter beaker and add an equal volume of the mercuric nitrate solution and mix. Then add solid sodium bicarbonate in moderate quantities, with gentle shaking only until frothing ceases and the mixture reacts alkaline to litmus. Filter at once through a dry

filter into a small dry flask or beaker. To the perfectly clear filtrate, add a pinch of zinc dust and one or two drops of concentrated hydrochloric acid. Shake the mixture and let it stand about five minutes. Then filter it through a small dry filter into a dry test tube or small beaker.

Measure from one to four cubic centimeters of the final filtrate* into a large test tube which should be graduated to indicate 12.5 and 25 cubic centimeters. If less than four cubic centimeters is used make up the volume to exactly four cubic centimeters with distilled water. Add one cubic centimeter of a twenty per cent solution of anhydrous sodium carbonate and four cubic centimeters of the picrate-picric acid solution. Plug the tube with cotton and place in a boiling water bath for ten minutes. Remove the tube, cool to room temperature, and dilute to the mark. Within one half hour, match the colored solution against the standard in a colorimeter.

4. Calibration of Tubes.

The tubes used in this experiment were calibrated to measure 12.5 cubic centimeters by weighing the amount of distilled water necessary to make a volume of 12.5 cubic centimeters at the room temperature. After several were calibrated by this method, the remainder were measured by a transfer of mercury from the calibrated tubes. The solutions requiring a greater dilution than 12.5 cubic centimeters were transferred to graduated cylinders.

5. The Standard.

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*The volume depends on the sugar content of the original urine. Five tenths to two milligrams of sugar are desired.

There are three standards that may be used satisfactorily for matching the color of the picramic acid: (1) pure glucose, (2) potassium dichromate solution, and (3) picramic acid.

A pure glucose standard gives a color that is most easily compared with that given by the unknown but on account of the difficulty of procuring a pure product, it could not be used for all the determinations. It was prepared by treating four cubic centimeters of 0.025 per cent glucose solution just as the final filtrate was treated.

For part of the determinations a solution of one half normal potassium dichromate was employed. It was standardized against the pure glucose solution and was set at the height which matched fifteen millimeters of the glucose standard. The dichromate is a permanent solution.

6. The Colorimeter.

The Kober[1] colorimeter was employed for comparing the colors. Daylight was used consistently through the experiment.

7. Calculations.

The calculation was made from this formula,

$$\frac{\text{Reading of Standard}}{\text{Reading of Unknown}} \times 0.025\% \times \text{volume} = \text{grams of sugar in sample.}$$

To facilitate rapid calculation, a table (see table III) was prepared which shows the per cent of glucose which corresponds to the different colorimeter readings. The table implies the use of a standard which represents four cubic centimeters of a solution containing 0.025 per cent of glucose, developed, diluted to 12.5

1. Kober, P. A., J. Biol. Chem., 1917, 29, 155.

cubic centimeters, and set at fifteen; the unknown represents four cubic centimeters of the final filtrate developed, diluted to 12.5 cubic centimeters and set at fifteen.

TABLE IV

Table for Calculations

Reading	Per cent	Reading	Per cent	Reading	Per cent	Reading	Per cent	Reading	Per cent
10.0	.0375	12.0	.0312	14.0	.0267	16.0	.0234	18.0	.0208
10.1	.0371	12.1	.0309	14.1	.0265	16.1	.0233	18.1	.0207
10.2	.0367	12.2	.0307	14.2	.0264	16.2	.0231	18.2	.0206
10.3	.0364	12.3	.0304	14.3	.0262	16.3	.0230	18.3	.0204
10.4	.0360	12.4	.0302	14.4	.0260	16.4	.0228	18.4	.0203
10.5	.0357	12.5	.0300	14.5	.0258	16.5	.0227	18.5	.0202
10.6	.0353	12.6	.0297	14.6	.0256	16.6	.0225	18.6	.0201
10.7	.0350	12.7	.0295	14.7	.0255	16.7	.0224	18.7	.0200
10.8	.0347	12.8	.0292	14.8	.0253	16.8	.0223	18.8	.0199
10.9	.0344	12.9	.0290	14.9	.0251	16.9	.0221	18.9	.0198
11.0	.0340	13.0	.0288	15.0	.0250	17.0	.0220	19.0	.0197
11.1	.0337	13.1	.0286	15.1	.0248	17.1	.0219	19.1	.0196
11.2	.0334	13.2	.0284	15.2	.0246	17.2	.0218	19.2	.0195
11.3	.0331	13.3	.0282	15.3	.0245	17.3	.0216	19.3	.0194
11.4	.0328	13.4	.0279	15.4	.0243	17.4	.0215	19.4	.0193
11.5	.0326	13.5	.0277	15.5	.0241	17.5	.0214	19.5	.0192
11.6	.0323	13.6	.0275	15.6	.0240	17.6	.0213	19.6	.0191
11.7	.0320	13.7	.0273	15.7	.0238	17.7	.0211	19.7	.0190
11.8	.0318	13.8	.0271	15.8	.0237	17.8	.0210	19.8	.0189
11.9	.0315	13.9	.0269	15.9	.0235	17.9	.0209	19.9	.0188

D. Discussion of Results.

The results of the glucose tolerance tests are given in Tables (V-XX). Of the ten subjects eight did not show a qualitative test even after the ingestion of 2½ grams of glucose per kilogram of body weight. In the case of I. T. the urinary specimens for the first and second hours each gave a very marked qualitative test after the ingestion of two grams of sugar per kilogram of body weight. The lowest tolerance was that of O. R., whose urine gave a positive qualitative test the first hour after the ingestion of 1½ grams of glucose per kilogram of body weight. Although this subject is not diabetic, there is a history of diabetes on the paternal side of her family.

For the fasting hour the elimination of sugar ranged from three to ten milligrams (see Tables V-XV) or from 0.0051 to 0.0630 per cent. This shows that glucose is a normal constituent of urine. It was because of this presence of sugar in normal urine that Benedict used the term "glycuresis" for the increase in sugar in urine. Even after the ingestion of only 1½ grams of glucose per kilogram of body weight, there was an increase in the elimination of sugar; however, the actual quantities excreted were very small. That the amount of sugar is independent of the volume is shown by the first part of Table VIII in which is recorded a volume of 203 cubic centimeters containing ten milligrams and a volume of 25.5 cubic centimeters also containing ten milligrams.

The case of I. T. (Table XIII) is a good example of how quickly the organism adjusts itself. During the fasting hour the elimination was eight milligrams, the first hour, 279 milligrams, the second hour, 128 milligrams, the third hour, seventeen milligrams,

and the last hour, ten milligrams. After each ingestion of glucose the sugar eliminated in the urine rises from the fasting level, reaches a maximum, usually in the first or second hour after ingestion, and falls again toward the fasting level. The rate and quantity of sugar excretion varies with the individual however; the curve is not always uniform.

After the breakfast alone the excretion of sugar was raised above the fasting level. In general when glucose was added to the breakfast the sugar excretion did not vary a great deal from that following the breakfast alone; but the excretion was greater than that following the same amount of glucose alone. This is shown by Table XXVI.

On an ordinary mixed diet there was an increase in the amount of glucose in the urine after meals and a decrease before the succeeding meal (See Table XXXIII). On a carbohydrate-rich diet there was a greater elimination of sugar during the first and second hours after meals and the amount of sugar in the urine did not fall to as low a level before the next meal as on an ordinary mixed diet. The curves are shown in Charts I-VI. For the six subjects of this experiment, the daily urinary output of sugar on an ordinary mixed diet varied from 342 to 471 milligrams (Table XXXIII). The carbohydrate-rich diet (See table XXXVIII) increased the total sugar in the urine in the case of L. C. from 384 to 685 milligrams; L. B., from 471 to 575; and E. A. from 420 to 530 milligrams. The increase of 363 to 1712 milligrams in the case of I. T. is far greater than the others. Her tolerance, as already shown, was lower than the others and her diet included more sugars than starch. These results on the daily excretion of sugar are

much lower than those obtained for men by Benedict. He gives data for only two men but there is no reason to suppose that his data is incorrect; one might expect a higher excretion in men.

Benedict's suggestion that the practice of taking a random specimen for a sugar test in life insurance examinations may lead to wrong deductions is illustrated by Table XXVIII, in which L. B. has six positive qualitative tests at various times through the day, although the total specimen for the day contains only 0.0574 per cent of sugar. If the specimen had been taken at one of these hours, she might have been refused life insurance.

E. Conclusions.

The results of these experiments seem to warrant the following conclusions in regard to healthy normal young women:

(a) The glucose tolerance varies; in eight out of the ten tested it exceeded $2\frac{1}{2}$ grams of glucose per kilogram of body weight; in one it was between two and $2\frac{1}{2}$ grams; and in the other it was between one and $1\frac{1}{2}$ grams of glucose per kilogram of body weight.

(b) In some cases the ingestion of food simultaneously with the ingestion of glucose seems to decrease the tolerance for glucose.

(c) The hourly sugar elimination following a carbohydrate-rich diet is greater than that on an ordinary mixed diet.

(d) The normal total daily excretion of sugar on an ordinary mixed diet is probably less than one half gram.

TABLE V

L. C. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g.per kg.	kg.		c.c.		per cent	mg.
$1\frac{1}{2}$	56.0	F*	15	-	0.0228	3
		1	148.5	-	0.0062	9
		2	140	-	0.0086	12
		3	26.5	-	0.0364	10
		4	19	-	0.0530	10
2	55.8	F	118	-	0.0065	8
		1	158	-	0.0101	16
		2	68	-	0.0398	27
		3	100	-	0.0187	19
		4	66	-	0.0192	13
$2\frac{1}{2}$	56.7	F	57.5	-	0.0096	6
		1	141	-	0.0114	16
		2	117	-	0.0307	36
		3	71.5	-	0.0387	27
		4	41	-	0.0590	24

*Fasting.

TABLE VI

L. B. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
$1\frac{1}{2}$	56.1	F	36.5	-	0.0237	9
		1	59	-	0.0234	14
		2	184.5	-	0.0094	17
		3	145	-	0.0090	13
		4	75	-	0.0164	12
2	55.3	F	15.5	-	0.0440	7
		1	15	-	0.0558	8
		2	16	-	0.0640	10
		3	16.5	-	0.0554	9
		4	——	-	——	——
$2\frac{1}{2}$	55.8	F	23.5	-	0.0187	4
		1	20	-	0.0466	9
		2	27.5	-	0.0500	14
		3	30.5	-	0.0428	13
		4	32	-	0.0371	12

TABLE VII

E. A. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
$1\frac{1}{2}$	58.7	F	25.5	-	0.0223	6
		1	133	-	0.0154	20
		2	31.5	-	0.0233	7
		3	81	-	0.0121	10
		4	———	-	———	—
2	58.2	F	21	-	0.0309	6
		1	26.5	-	0.0331	9
		2	52	-	0.0146	8
		3	163	-	0.0108	18
		4	77	-	0.0127	10
$2\frac{1}{2}$	58.7	F	23.5	-	0.0331	8
		1	27	-	0.0454	12
		2	54	-	0.0398	21
		3	28	-	0.0524	15
		4	28	-	0.0528	15

TABLE VIII

I. S. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
$1\frac{1}{2}$	48.2	F	203	-	0.0051	10
		1	25.5	-	0.0375	10
		2	32	-	0.0312	10
		3	35	-	0.0203	7
		4	19.5	-	0.0245	5
2	46.8	F	95	-	0.0088	8
		1	63	-	0.0204	13
		2	35.5	-	0.0199	7
		3	20	-	0.0430	9
		4	13	-	0.0438	6
$2\frac{1}{2}$	47.2	F	19	-	0.0267	5
		1	44.5	-	0.0233	10
		2	21.5	-	0.0516	11
		3	24	-	0.0554	13
		4	32	-	0.0520	17

TABLE IX

B. H. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
1½	56.2	F	20.5	-	0.0375	8
		1	16.5	-	0.0502	8
		2	22.5	-	0.0600	14
		3	27.5	-	0.0404	11
		4	54.0	-	0.0187	10
2	57.0	F	25	-	0.0266	7
		1	23.5	-	0.0454	11
		2	19.5	-	0.0450	9
		3	28.5	-	0.0394	11
		4	———		———	——
2½	55.4	F	18	-	0.0340	6
		1	18	-	0.0428	8
		2	20.5	-	0.0524	11
		3	23.5	-	0.0375	9
		4	27.5	-	0.0295	8

TABLE X

J. H. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
$1\frac{1}{2}$	47.8	F	18	-	0.0416	7
		1	175	-	0.0066	11
		2	87	-	0.0082	7
		3	42	-	0.0151	6
		4	25	-	0.0209	6
2	46.3	F	42	-	0.0134	6
		1	116	-	0.0077	9
		2	143	-	0.0082	12
		3	114	-	0.0120	14
		4	58	-	0.0122	8
$2\frac{1}{2}$	46.6	F	51	-	0.0162	8
		1	208	-	0.0076	16
		2	139	-	0.0076	18
		3	108	-	0.0127	13
		4	87	-	0.0123	9

TABLE XI

E. B. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
1½	53.0	F	21.5	-	0.0406	9
		1	18.5	-	0.0584	11
		2	24.5	-	0.0482	12
		3	23	-	0.0404	9
		4	63	-	0.0151	9
2	52.9	F	31.5	-	0.0193	6
		1	22.5	-	0.0290	7
		2	34	-	0.0243	8
		3	49	-	0.0202	10
		4	76	-	0.0078	6
2½	52.7	F	24	-	0.0203	5
		1	16.5	-	0.0600	10
		2	19.5	-	0.0442	9
		3	20	-	0.0561	11
		4	20	-	0.0510	10

TABLE XII

E. W. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
$1\frac{1}{2}$	55.0	F	40	-	0.0211	8
		1	96	-	0.0128	12
		2	26	-	0.0347	9
		3	114	-	0.0126	14
		4	———		———	——
2	56.5	F	27	-	0.0238	6
		1	45.5	-	0.0238	11
		2	40.5	-	0.030[illegible]	12
		3	25.5	-	0.0363	8
		4	55	-	0.0140	8
$2\frac{1}{2}$	55.9	F	63	-	0.0127	8
		1	17	-	0.0750	13
		2	21	-	0.0772	16
		3	33	-	0.0492	16
		4	44	-	0.0318	15

TABLE XIII

I. T. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
$1\frac{1}{2}$	53.0	F	38	-	0.0191	7
		1	183	-	0.0109	20
		2	108.5	-	0.0116	13
		3	26	-	0.0326	8
		4	21.5	-	0.0364	8
2	52.8	F	19	-	0.0384	5
		1	25.5	-	0.0114	3
		2	83	-	0.0496	40
		3	17.5	-	0.0568	10
		4	15	-	0.0600	9
$2\frac{1}{2}$	53.0	F	24.5	-	0.0318	8
		1	127	++	0.2000	279
		2	91	+	0.1408	128
		3	30	-	0.0564	17
		4	22.5	-	0.0460	10

TABLE XIV

O. R. - Glucose Tolerance

Glucose	Body Weight	Hour	Urine			
			Volume	Sugar		
				Qualitative	Quantitative	
g. per kg.	kg.		c.c.		per cent	mg.
1	57.5	F	12	±	0.0630	8
		1	32	-	0.0406	13
		2	96	-	0.0151	14
		3	20	-	0.0462	9
		4	22.5	-	0.0456	10
1½	57.6	F	42	-	0.0203	9
		1	82	+	0.0992	81
		2	119	-	0.0255	30
		3	38	-	0.0246	9
		4	36	-	0.0248	9

TABLE XV

Summary of Tables V-XIV

Glucose	Hour	L.C.	L.B.	E.A.	I.S.	B.H.	J.H.	E.B.	E.W.	I.T.	O.R.
g./k.		mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
$1\frac{1}{2}$	F	3	9	6	10	8	7	9	8	7	9
	1	9	14	20	10	8	11	11	12	20	81
	2	12	17	7	10	14	7	12	9	13	30
	3	10	13	10	7	11	6	9	14	8	9
	4	10	12	--	5	10	6	9	--	8	9
2	F	8	7	6	8	7	6	6	6	5	
	1	16	8	9	13	11	9	7	11	3	
	2	27	10	8	7	9	12	8	12	40	
	3	19	9	18	9	11	14	10	8	10	
	4	13	--	10	6	--	8	6	8	9	
$2\frac{1}{2}$	F	6	4	8	5	6	8	5	8	8	
	1	16	9	12	10	8	16	10	13	279	
	2	36	14	21	11	11	18	9	16	128	
	3	27	13	15	13	9	13	11	16	17	
	4	24	12	15	17	8	9	10	15	10	

TABLE XVI

L. C. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	13.5	-	0.0386	5
	1	16	-	0.0360	6
	2	24	-	0.0426	10
	3	31	-	0.0398	12
	4	31	-	0.0360	11
Breakfast with 2g. per kg. glucose					
	F	14	-	0.0334	5
	1	34	-	0.0402	14
	2	173	-	0.0106	18
	3	27.5	-	0.0542	15
	4	30	-	0.0510	15
Glucose (2g. per kg.)					
	F	118	-	0.0065	8
	1	158	-	0.0101	16
	2	68	-	0.0398	27
	3	100	-	0.0187	19
	4	66	-	0.0192	13

TABLE XVII

L. B. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	13.5	-	0.0636	9
	1	15	-	0.0824	12
	2	33	-	0.0590	19
	3	25	-	0.0384	10
	4	30	-	0.0347	10
Breakfast with 2g. per kg. glucose					
	F	24	-	0.0337	8
	1	22	-	0.0462	10
	2	55.5	-	0.0258	14
	3	50.5	-	0.0278	14
	4	63.5	-	0.0224	14
Glucose (2g. per kg.)					
	F	15.5	-	0.0440	7
	1	15	-	0.0558	8
	2	16	-	0.0640	10
	3	16.5	-	0.0554	9
	4	----	-	------	--

TABLE XVIII

E. A. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	30	-	0.0400	12
	1	28	-	0.0520	15
	2	28	-	0.0500	14
	3	38	-	0.0416	16
	4	31	-	0.0430	13
Breakfast with 2g. per kg. glucose					
	F	50	-	0.0282	14
	1	37	-	0.0426	16
	2	57	-	0.0300	17
	3	20	-	0.0474	10
	4	74	-	0.0375	28
Glucose (2g. per kg.)					
	F	21	-	0.0309	6
	1	26.5	-	0.0331	9
	2	52	-	0.0146	8
	3	163	-	0.0108	18
	4	77	-	0.0127	10

TABLE XIX

I. S. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	34.5	-	0.0446	15
	1	27	-	0.0564	15
	2	31	-	0.0438	14
	3	44	-	0.0340	15
	4	--		------	--
Breakfast with 2g. per kg. glucose					
	F	16.5	-	0.0347	6
	1	24	-	0.0446	11
	2	26.5	-	0.0364	10
	3	19	-	0.0492	9
	4	24	-	0.0448	11
Glucose (2g. per kg.)					
	F	95	-	0.0088	8
	1	63	-	0.0204	13
	2	35.5	-	0.0199	7
	3	20	-	0.0430	9
	4	13	-	0.0438	6

TABLE XX

B. H. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	32	-	0.0662	21
	1	25	-	0.0856	22
	2	31	-	0.0756	23
	3	41	-	0.0560	23
	4	24	-	0.0788	19
Breakfast with 2g. per kg. glucose					
	F	30	-	0.0376	11
	1	24	-	0.0616	15
	2	22	-	0.0685	15
	3	33.0	-	0.0536	18
	4	34.0	-	0.0504	17
Glucose (2g. per kg.)					
	F	25	-	0.0366	7
	1	23.5	-	0.0454	11
	2	19.5	-	0.0450	9
	3	28.5	-	0.0394	11
	4	----		------	--

TABLE XXI

J. H. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	15	-	0.0520	8
	1	22	-	0.0546	12
	2	25	-	0.0542	14
	3	29	-	0.0492	14
	4	31	-	0.0357	11
Breakfast with 2g. per kg. glucose					
	F	60	-	0.0140	8
	1	50	-	0.0267	13
	2	73	-	0.0253	18
	3	75	-	0.0211	16
	4	47	-	0.0279	13
Glucose (2g. per kg.)					
	F	42	-	0.0134	6
	1	116	-	0.0077	9
	2	143	-	0.0082	12
	3	114	-	0.0120	14
	4	58	-	0.0122	8

TABLE XXII

E. B. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	43	-	0.0162	7
	1	22	-	0.0350	8
	2	22	-	0.0554	12
	3	25.5	-	0.0506	13
	4	29	-	0.0454	13
Breakfast with 2g. per kg. glucose					
	F	53	-	0.0141	7
	1	17.5	-	0.0398	7
	2	21.5	-	0.0480	10
	3	21	-	0.0564	12
	4	21.5	-	0.0512	11
Glucose (2g. per kg.)					
	F	31.5	-	0.0193	6
	1	22.5	-	0.0290	7
	2	34	-	0.0243	8
	3	49	-	0.0202	10
	4	76	-	0.0078	6

TABLE XXIII

E. W. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	25	-	0.0304	8
	1	26.5	-	0.0564	15
	2	44	-	0.0364	16
	3	90.5	-	0.0178	16
	4	69	-	0.0185	13
Breakfast with 2g. per kg. glucose					
	F	58	-	0.0228	13
	1	89	-	0.0300	27
	2	115	-	0.0231	27
	3	28.5	-	0.0531	15
	4	53	-	0.0245	13
Glucose (2g. per kg.)					
	F	27	-	0.0238	6
	1	45.5	-	0.0238	11
	2	40.5	-	0.0300	12
	3	25.5	-	0.0363	8
	4	55	-	0.0140	8

TABLE XXIV

I. T. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	66	-	0.0114	8
	1	28.5	-	0.0286	8
	2	37.0	-	0.0378	14
	3	36.5	-	0.0340	12
	4	38	-	0.0295	11
Breakfast with 2g. per kg. glucose					
	F	54.5	-	0.0194	11
	1	47	+	0.3056	144
	2	93	±	0.0558	52
	3	29	±	0.0630	18
	4	28	-	0.0450	13
Glucose (2g. per kg.)					
	F	19	-	0.0284	5
	1	25.5	-	0.0114	3
	2	83	-	0.0496	40
	3	17.5	-	0.0568	10
	4	15	-	0.0600	9

TABLE XXV

O. R. - Glucose Tolerance with Standard Breakfast

	Hour	Urine			
		Volume	Sugar		
			Qualitative	Quantitative	
		c.c.		per cent	mg.
Breakfast					
	F	39	-	0.0211	8
	1	47	-	0.0228	11
	2	163	-	0.0125	20
	3	28.5	-	0.0394	11
	4	40	-	0.0241	10
Breakfast with $1\frac{1}{2}$ g. per kg. glucose					
	F	21.5	-	0.0347	7
	1	37	+	0.2024	75
	2	209	-	0.0290	61
	3	24.5	-	0.0576	14
	4	28	-	0.0500	14
Glucose($1\frac{1}{2}$ g. per kg.)					
	F	42	-	0.0203	9
	1	82	+	0.0992	81
	2	119	-	0.0255	30
	3	38	-	0.0246	9
	4	36	-	0.0248	9

TABLE XXVI

Summary of Tables XVI-XXV

Hour	L.C.	L.B.	E.A.	I.S.	B.H.	J.H.	E.B.	E.W.	I.T.
	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Breakfast									
F	5	9	12	15	21	8	7	8	8
1	6	12	15	15	22	12	8	15	8
2	10	19	14	14	23	14	12	16	14
3	12	10	16	15	23	14	13	16	12
4	11	10	13	--	19	11	13	13	11
Breakfast with 2g. per kg. glucose									
F	5	8	14	6	11	8	7	13	11
1	14	10	16	11	15	13	7	27	144
2	18	14	17	10	15	18	10	27	52
3	15	14	10	9	18	16	12	15	18
4	15	14	28	11	17	13	11	13	13
Glucose (2g. per kg.)									
F	8	7	6	8	7	6	6	6	5
1	16	8	9	13	11	9	7	11	3
2	27	10	8	7	9	12	8	12	40
3	19	9	18	9	11	14	10	8	10
4	13	--	10	6	--	8	6	8	9

TABLE XXVII

L. C. - Hourly Elimination of Sugar in Urine on Ordinary Mixed Diet.

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	132	-	0.0084	11
8 A.M.- 9 A.M.	169	-	0.0136	23
9 A.M.-10 A.M.	72	-	0.0271	20
10 A.M.-11 A.M.	124	-	0.0143	18
11 A.M.-12 M.	78	-	0.0177	14
12 M. - 1 P.M.	44	-	0.0290	13
1 P.M.- 2 P.M.	62	-	0.0344	21
2 P.M.- 3 P.M.	26	-	0.0796	21
3 P.M.- 4 P.M.	35	-	0.0700	25
4 P.M.- 5 P.M.	31	-	0.0492	15
5 P.M.- 6 P.M.	27	-	0.0406	11
6 P.M.- 7 P.M.	25	-	0.0510	13
7 P.M.- 8 P.M.	33	±	0.0684	23
8 P.M.- 9 P.M.	19	±	0.1059	20
9 P.M.-10 P.M.	25	±	0.0978	24
10 P.M.- 7 A.M.	184	-	0.0594	109
7 A.M.- 7 A.M.	1086		0.0350	384

Breakfast: Grape fruit, sugar, toast, poached egg. . . . . 7:30 A.M.

Lunch: Buttered peas, fried potatoes, bacon, bread, milk, peaches . . . . .12:15 P.M.

Dinner: Pork chop, mashed potato, gravy, bread, kraut, milk, apple pie, chocolate candy . . . . 6:25 P.M.

TABLE XXVIII

L. B. - Hourly Elimination of Sugar in Urine on Ordinary Mixed Diet.

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	18	-	0.0357	6
8 A.M.- 9 A.M.	21	-	0.0706	15
9 A.M.-10 A.M.	36	-	0.0568	20
10 A.M.-11 A.M.	72	-	0.0284	20
11 A.M.-12 M.	83	-	0.0228	19
12 M. - 1 P.M.	31	-	0.0506	16
1 P.M.- 2 P.M.	30	+	0.1744	52
2 P.M.- 3 P.M.	31	+	0.1200	37
3 P.M.- 4 P.M.	31	-	0.0860	27
4 P.M.- 5 P.M.	38	-	0.0512	19
5 P.M.- 6 P.M.	42	-	0.0353	15
6 P.M.- 7 P.M.	30	-	0.0490	15
7 P.M.- 8 P.M.	23	+	0.1456	33
8 P.M.- 9 P.M.	29	+	0.1004	29
9 P.M.-10 P.M.	26	+	0.1272	33
10 P.M.-11 P.M.	26	+	0.0948	26
11 P.M.- 7 A.M.	253	-	0.0350	89
7 A.M.- 7 A.M.	820	-	0.0574	471

Breakfast: Orange, puffed wheat, milk, sugar, cocoa . . . 7:30 A.M.

Lunch: Pea soup, crackers, bread, butter, tomato sweet pickle, apple sauce, angel cake . . . . 12:15 P.M.

Dinner: Hash, bread, lettuce salad, plum jam, oatmeal cookie, apricots . . . . 6:15 P.M.

TABLE XXIX

E. A. - Hourly Elimination of Sugar in Urine on Ordinary Mixed Diet.

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	21	-	0.0652	14
8 A.M.- 9 A.M.	89	-	0.0326	28
9 A.M.-10 A.M.	41	-	0.0594	24
10 A.M.-11 A.M.	40	-	0.0406	16
11 A.M.-12 M.	66	-	0.0241	16
12 M. - 1 P.M.	58	-	0.0412	24
1 P.M.- 2 P.M.	116	-	0.0243	28
2 P.M.- 3 P.M.	53	-	0.0416	22
3 P.M.- 4 P.M.	91	-	0.0210	20
4 P.M.- 5 P.M.	55	-	0.0194	11
5 P.M.- 6 P.M.	32	-	0.0274	9
6 P.M.- 7 P.M.	39	-	0.0328	13
7 P.M.- 8 P.M.	20	-	0.0682	14
8 P.M.- 9 P.M.	23	+	0.1324	30
9 P.M.-10 P.M.	19	+	0.1168	22
10 P.M.-11 P.M.	21	±	0.1004	21
11 P.M.- 7 A.M.	155	-	0.0694	108
7 A.M.- 7 A.M.	839	-	0.0500	420

Breakfast: Prunes, cornflakes, milk, French toast, syrup, coffee, cream . . . . 7:30 A.M.
Lunch: Welsh rarebit, Graham bread, butter, doughnut, apple sauce candy . . . . 12:15 P.M.
Dinner: Roast beef, mashed potato, gravy, asparagus, lettuce salad, Graham bread, butter, hot fudge ice cream, cookies . . 6:15P.M.

TABLE XXX

I. S. - Hourly Elimination of Sugar in Urine on Ordinary Mixed Diet.

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	37	-	0.0353	13
8 A.M.- 9 A.M.	25	-	0.0512	13
9 A.M.-10 A.M.	31	-	0.0428	13
10 A.M.-11 A.M.	26	-	0.0418	11
11 A.M.-12 M.	24	-	0.0367	9
12 M. - 1 P.M.	22	-	0.0430	9
1 P.M.- 2 P.M.	21	-	0.0646	14
2 P.M.- 3 P.M.	42	-	0.0318	13
3 P.M.- 4 P.M.	52	-	0.0326	17
4 P.M.- 5 P.M.	26	-	0.0384	10
5 P.M.- 6 P.M.	33	-	0.0328	11
6 P.M.- 7 P.M.	65	-	0.0394	26
7 P.M.- 8 P.M.	112	-	0.0320	36
8 P.M.- 9 P.M.	119	-	0.0312	37
9 P.M.-10 P.M.	62	-	0.0462	29
10 P.M.-11 P.M.	63	-	0.0120	8
11 P.M.- 7 A.M.	275	-	0.0264	73
7 A.M.- 7 A.M.	835	-	0.0409	342

Breakfast: Shredded wheat, biscuit, banana, milk, sugar, butter, cocoa . . . . 7:30 A.M.

Lunch: Egg, cottage cheese, bread, butter, apple sauce . 12:15 P.M.

Dinner: Potato, bread, butter, pickle, pineapple ice, cookies, coffee, sugar, cream . . . . 6:15 P.M.

TABLE XXXI

Q. R. - Hourly Elimination of Sugar in Urine on Ordinary Mixed Diet.

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	21	-	0.0412	9
8 A.M.- 9 A.M.	229	-	0.0048	11
9 A.M.-10 A.M.	61	-	0.0235	14
10 A.M.-11 A.M.	30	-	0.0318	10
11 A.M.-12 M.	33	-	0.0284	9
12 M. - 1 P.M.	28	-	0.0320	9
1 P.M.- 2 P.M.	35	-	0.0390	14
2 P.M.- 3 P.M.	24	-	0.0516	12
3 P.M.- 4 P.M.	23	-	0.0546	13
4 P.M.- 5 P.M.	30	-	0.0410	13
5 P.M.- 6 P.M.	23	-	0.0547	13
6 P.M.- 7 P.M.	35	-	0.0546	19
7 P.M.- 8 P.M.	82	-	0.0538	44
8 P.M.- 9 P.M.	37	+	0.1260	47
9 P.M.-10 P.M.	30	+	0.1200	36
10 P.M.-11 P.M.	25	+	0.1146	29
11 P.M.- 7 A.M.	210	-	0.0634	133
7 A.M.- 7 A.M.	956	-	0.0455	435

Breakfast: Biscuit, butter, syrup, banana . . . . 7:30 A.M.

Lunch: Meat salad, bread, muffin, butter, jam . . . . 12:15 P.M.

Dinner: Bread, butter, baked ham, pickle, orange, apple, cookies . . . . 6:15 P.M.

TABLE XXXII

I. T. - Hourly Elimination of Sugar in Urine on Ordinary Mixed Diet.

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	28	-	0.0422	12
8 A.M.- 9 A.M.	30	-	0.0456	14
9 A.M.-10 A.M.	41	-	0.0398	16
10 A.M.-11 A.M.	38	-	0.0416	16
11 A.M.-12 M.	31	-	0.0474	15
12 M. - 1 P.M.	28	±	0.0700	20
1 P.M.- 2 P.M.	25	+	0.0832	21
2 P.M.- 3 P.M.	26	+	0.0780	20
3 P.M.- 4 P.M.	26	±	0.0580	15
4 P.M.- 5 P.M.	32	-	0.0408	13
5 P.M.- 6 P.M.	17	+	0.0675	11
6 P.M.- 7 P.M.	19	+	0.1000	19
7 P.M.- 8 P.M.	13	+	0.0780	10
8 P.M.- 9 P.M.	30	+	0.0984	30
9 P.M.-10 P.M.	32	+	0.0630	20
10 P.M.-11 P.M.	43	-	0.0272	11
11 P.M.- 7 A.M.	328	-	0.0304	100
7 A.M.- 7 A.M.	787	-	0.0461	363

Breakfast: Shredded wheat, milk, toast, butter, cocoa, bacon . . . . 7:30 A.M.
Lunch: Meat loaf, gravy, escalloped corn, biscuits, bread, butter, jam . . . . .12:15 P.M.
Dinner: Fruit cocktail, veal cutlet, gravy, potatoes, gelatin salad, whipped cream, cake, ice cream . . . . 6:25 P.M.

TABLE XXXIII

Summary of Results Showing Hourly Urinary Elimination of Sugar (milligrams) on an Ordinary Mixed Diet.

Hour	L.C.	I.T.	L.B.	O.R.	E.A.	I.S.
	mg.	mg.	mg.	mg.	mg.	mg.
7 A.M.- 8 A.M.	11	12	6	9	14	13
8 A.M.- 9 A.M.	23	14	15	11	28	13
9 A.M.-10 A.M.	20	16	20	14	24	13
10 A.M.-11 A.M.	18	16	20	10	16	11
11 A.M.-12 M.	14	15	19	9	16	9
12 M. - 1 P.M.	13	20	16	9	24	9
1 P.M.- 2 P.M.	21	21	52	14	28	14
2 P.M.- 3 P.M.	21	20	37	12	22	13
3 P.M.- 4 P.M.	25	15	27	13	20	17
4 P.M.- 5 P.M.	15	13	19	13	11	10
5 P.M.- 6 P.M.	11	11	15	13	9	11
6 P.M.- 7 P.M.	13	19	15	19	13	26
7 P.M.- 8 P.M.	23	10	33	44	14	36
8 P.M.- 9 P.M.	20	30	29	47	30	37
9 P.M.-10 P.M.	24	20	33	36	22	29
10 P.M.-11 P.M.	--	11	26	29	21	8
11 P.M.- 7 A.M.	109	100	89	133	108	73
7 A.M.- 7 A.M.	384	363	471	435	420	342

TABLE XXXIV

L.C. - Hourly Elimination of Sugar in Urine on Carbohydrate-rich diet

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	41	-	0.0347	14
8 A.M.- 9 A.M.	62	+	0.0940	58
9 A.M.-10 A.M.	45	+	0.1292	58
10 A.M.-11 A.M.	42	+	0.1312	55
11 A.M.-12 M.	39	+	0.0948	37
12 M. - 1 P.M.	39	±	0.0844	33
1 P.M.- 2 P.M.	40	+	0.0856	34
2 P.M.- 3 P.M.	37	±	0.0844	31
3 P.M.- 4 P.M.	37	±	0.0776	29
4 P.M.- 5 P.M.	31	-	0.0700	22
5 P.M.- 6 P.M.	20	-	0.0728	15
6 P.M.- 7 P.M.	18	±	0.1040	18
7 P.M.- 8 P.M.	16	+	0.1944	31
8 P.M.- 9 P.M.	18	+	0.2376	43
9 P.M.-10 P.M.	19	+	0.2064	39
10 P.M.-11 P.M.	18	+	0.1872	34
11 P.M.- 7 A.M.	358	-	0.0375	134
7 A.M.- 7 A.M.	880	-	0.0778	685

Breakfast: Pancakes, Karo syrup, cocoa, grape fruit, sugar, butter . . . . 7:30 A.M.
Lunch: Navy beans, bread, banana, cream, sugar, milk, cookies . . . . .12:15 P.M.
Dinner: Spanish rice, biscuit, Karo syrup, butter, chocolate pie, milk . . . . 6:25 P.M.

TABLE XXXV

L.B. - Hourly Elimination of Sugar in Urine on Carbohydrate-rich diet

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	18	-	0.0502	9
8 A.M.- 9 A.M.	23	-	0.0700	16
9 A.M.-10 A.M.	20	-	0.0892	18
10 A.M.-11 A.M.	25	-	0.0864	22
11 A.M.-12 M.	46	-	0.0436	20
12 M. - 1 P.M.	92	-	0.0251	23
1 P.M.- 2 P.M.	20	+	0.1816	36
2 P.M.- 3 P.M.	30	+	0.1272	38
3 P.M.- 4 P.M.	24	+	0.1552	37
4 P.M.- 5 P.M.	30	+	0.1208	36
5 P.M.- 6 P.M.	31	-	0.0852	26
6 P.M.- 7 P.M.	21	-	0.0900	19
7 P.M.- 8 P.M.	48	+	0.1040	50
8 P.M.- 9 P.M.	26	+	0.1084	28
9 P.M.-10 P.M.	32	-	0.0750	24
10 P.M.-11 P.M.	37	-	0.0590	22
11 P.M.- 7 A.M.	318	-	0.0474	151
7 A.M.- 7 A.M.	841	-	0.0683	575

Breakfast: Pancakes, Karo syrup, cocoa, orange, sugar . . .7:30 A.M.

Lunch: Fried potatoes, bread, butter, prunes, sugar, milk, cookies . . . . 12:15 P.M.

Dinner: Spanish rice, bread, Karo syrup, bread pudding, cream . . . . 6:15 P.M.

TABLE XXXVI

E.A. - Hourly Elimination of Sugar in Urine on Carbohydrate-rich diet

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	31	-	0.0486	15
8 A.M.- 9 A.M.	39	-	0.0768	30
9 A.M.-10 A.M.	49	-	0.0792	29
10 A.M.-11 A.M.	44	-	0.0500	22
11 A.M.-12 M.	171	-	0.0117	20
12 M. - 1 P.M.	95	-	0.0323	31
1 P.M.- 2 P.M.	26	+	0.1200	31
2 P.M.- 3 P.M.	31	+	0.1228	38
3 P.M.- 4 P.M.	26	±	0.0900	23
4 P.M.- 5 P.M.	28	-	0.0864	24
5 P.M.- 6 P.M.	38	-	0.0558	21
6 P.M.- 7 P.M.	38	-	0.0636	24
7 P.M.- 8 P.M.	37	-	0.0774	29
8 P.M.- 9 P.M.	28	±	0.1136	32
9 P.M.-10 P.M.	23	±	0.1228	28
10 P.M.-11 P.M.	13	-	0.0824	11
11 P.M.- 7 A.M.	610	-	0.0200	122
7 A.M.- 7 A.M.	1327	-	0.0324	530

Breakfast: Orange, sugar, cornflakes, cream, French toast, syrup, coffee . . . . 7:30 A.M.
Lunch: Bread hash, lima beans, Graham bread, sugar, butter, tea, milk chocolate candy, raspberry sauce . . . . .12:15 P.M.
Dinner: Mashed potatoes, gravy, roast beef, lettuce salad, salad dressing, sugar, bread, butter, coffee, cream . . . . 6:15 P.M.

TABLE XXXVII

I.T. - Hourly Elimination of Sugar in Urine on Carbohydrate-rich diet

Hour	Urine			
	Volume	Sugar		
		Qualitative	Quantitative	
	c.c.		per cent	mg.
7 A.M.- 8 A.M.	25	-	0.0624	16
8 A.M.- 9 A.M.	23	-	0.0700	16
9 A.M.-10 A.M.	31	-	0.0439	14
10 A.M.-11 A.M.	34	-	0.0295	10
11 A.M.-12 M.	16	-	0.0400	6
12 M. - 1 P.M.	16	-	0.0267	9
1 P.M.- 2 P.M.	52	++	0.8928	464
2 P.M.- 3 P.M.) 3 P.M.- 4 P.M.)	48	+	0.2048	98
4 P.M.- 5 P.M.	17	-	0.0714	12
5 P.M.- 6 P.M.	17	-	0.0416	7
6 P.M.- 7 P.M.	22	-	0.0780	17
7 P.M.- 8 P.M.	54	+++	1.6640	899
8 P.M.- 9 P.M.	58	+	0.0940	55
9 P.M.-10 P.M.	30	-	0.0528	16
10 P.M.-11 P.M.	20	-	0.0706	14
11 P.M.- 7 A.M.	438	-	0.0135	57
7 A.M.- 7 A.M.	901	-	0.1900	1712

Breakfast: Cream of wheat, milk, sugar, toast, fried mush, butter, cocoa . . . . .7:30 A.M.
Lunch: Mashed potatoes, sour kraut, bread, butter, apple sauce, tea, sugar, Karo syrup . . . . .12:15 P.M.
Dinner: Creamed potatoes, bread, vegetable salad, peas, butter, coffee, sugar, syrup, biscuit, orange, gelatin . . . . 6:25 P.M.

TABLE XXXVIII

Summary of Results Showing Hourly Urinary Elimination of Sugar (milligrams) on a Carbohydrate-rich Diet.

Hour	L.C.	I.T.	L.B.	E.A.
	mg.	mg.	mg.	mg.
7 A.M.- 8 A.M.	14	16	9	15
8 A.M.- 9 A.M.	58	16	16	30
9 A.M.-10 A.M.	58	14	18	29
10 A.M.-11 A.M.	55	10	22	22
11 A.M.-12 M.	37	6	20	20
12 M. - 1 P.M.	33	9	23	31
1 P.M.- 2 P.M.	34	464	36	31
2 P.M.- 3 P.M.	31	98	38	38
3 P.M.- 4 P.M.	29		37	23
4 P.M.- 5 P.M.	22	12	36	24
5 P.M.- 6 P.M.	15	7	26	21
6 P.M.- 7 P.M.	18	17	19	24
7 P.M.- 8 P.M.	31	899	50	29
8 P.M.- 9 P.M.	43	55	28	32
9 P.M.-10 P.M.	39	16	24	28
10 P.M.-11 P.M.	34	14	22	11
11 P.M.- 7 A.M.	134	59	151	122
7 A.M.- 7 A.M.	685	1712	575	530

CHART I

L.C.-Hourly Elimination of Sugar on an Ordinary Mixed Diet

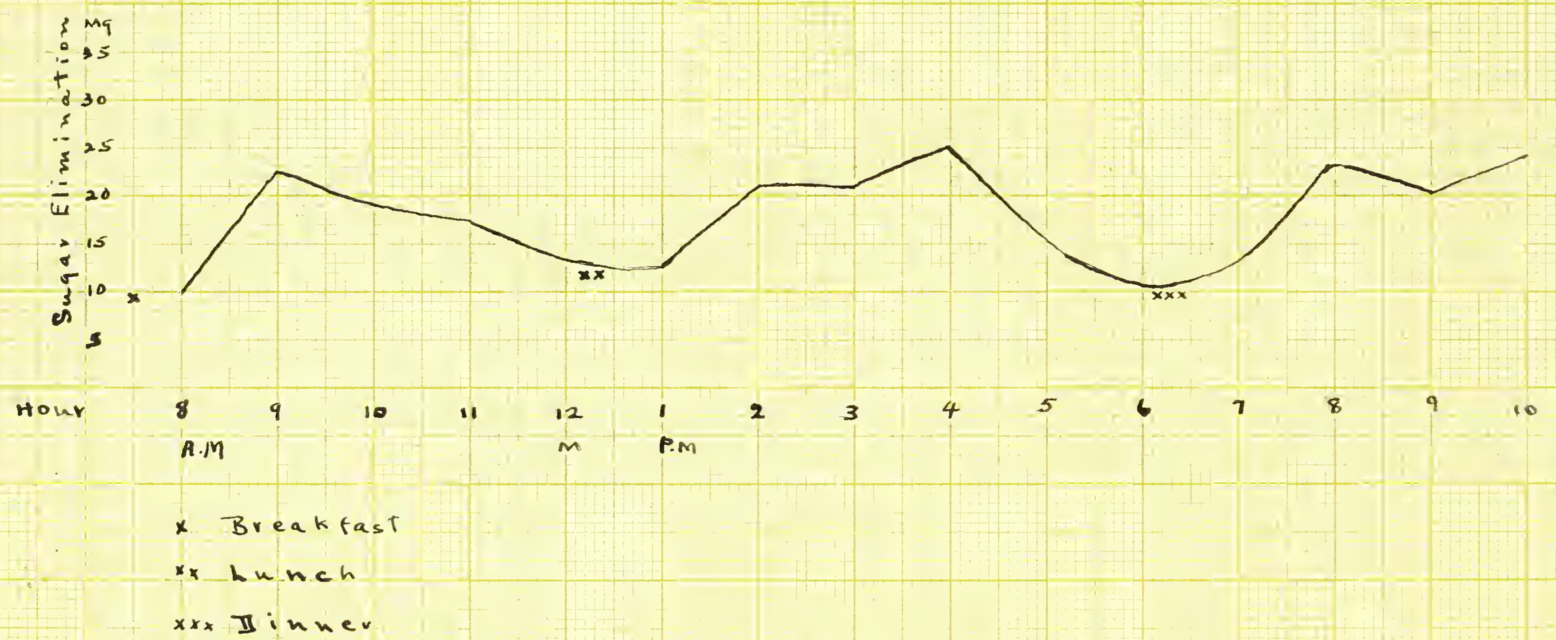


CHART II

L.B.- Hourly Elimination of Sugar on an Ordinary Mixed Diet

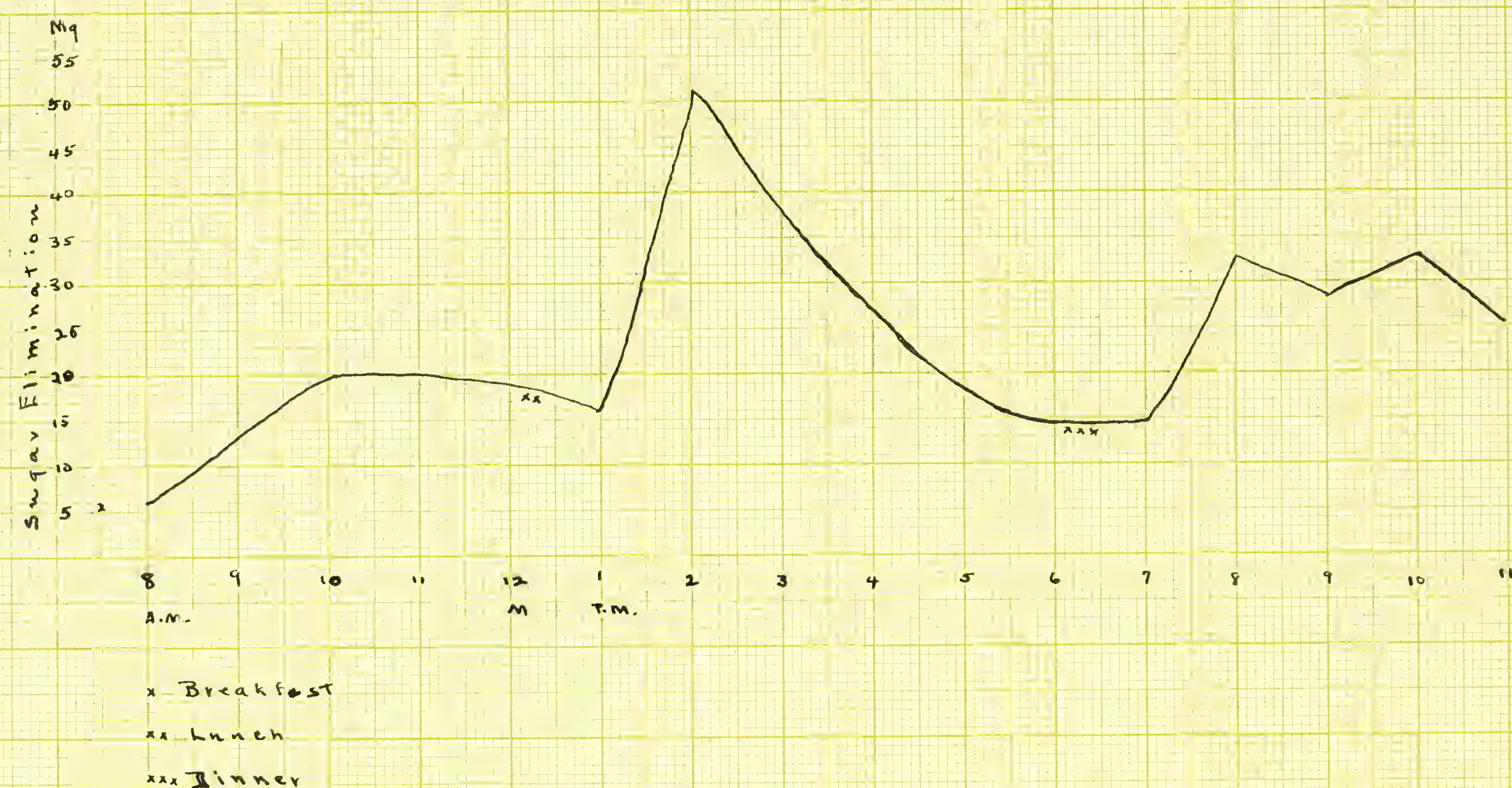


CHART III

E. A.- Hourly Elimination of Sugar on an Ordinary Mixed Diet

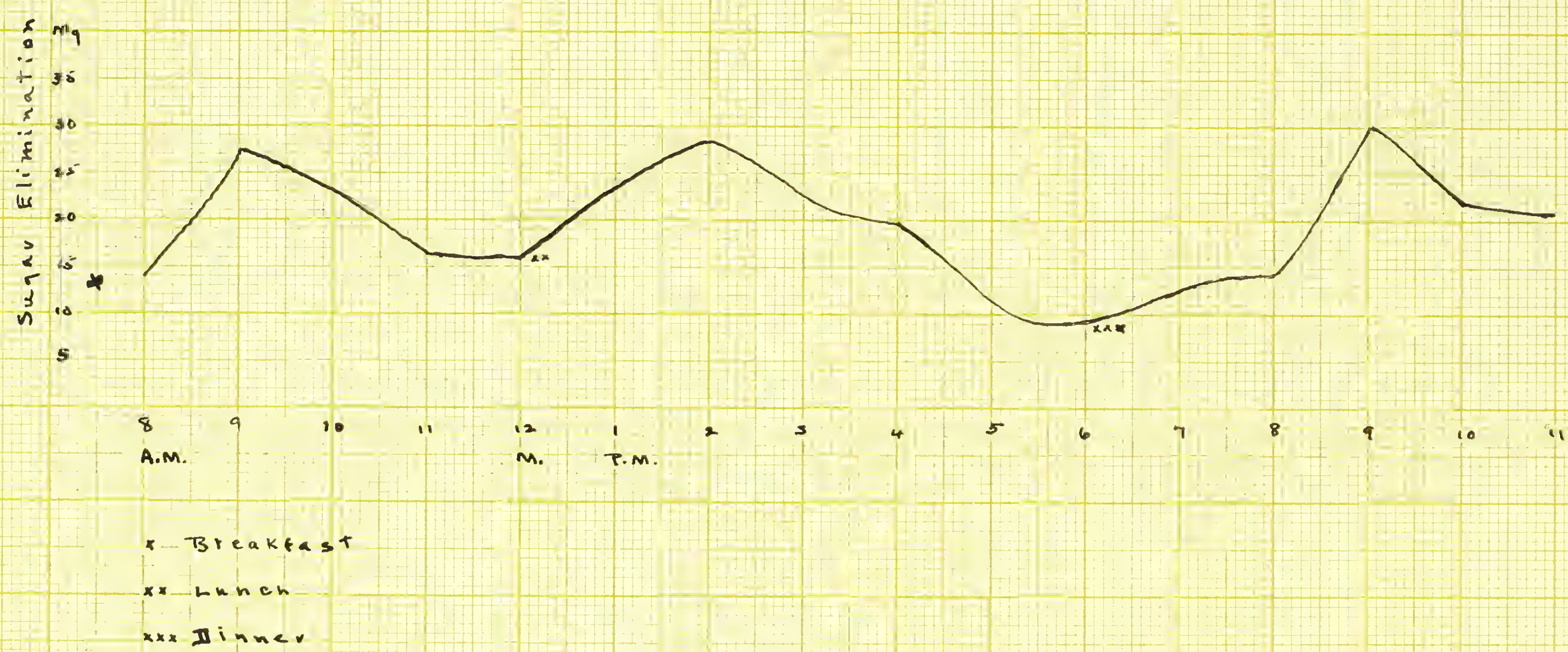


CHART IV

L.C.- Hourly Elimination of Sugar on a Carbohydrate-rich Diet

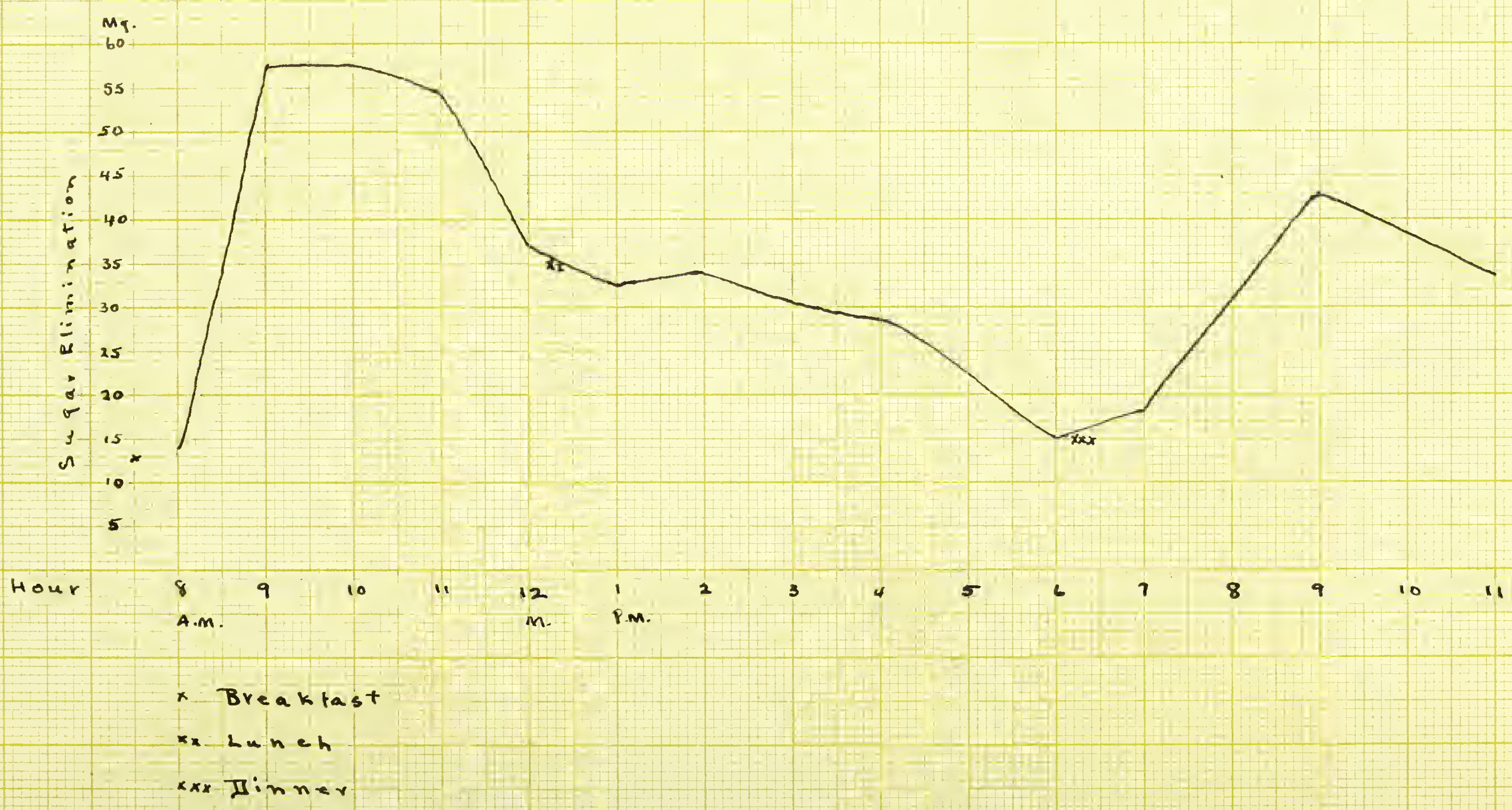


CHART V

L.B.- Hourly Elimination of Sugar on a Carbohydrate-rich Diet

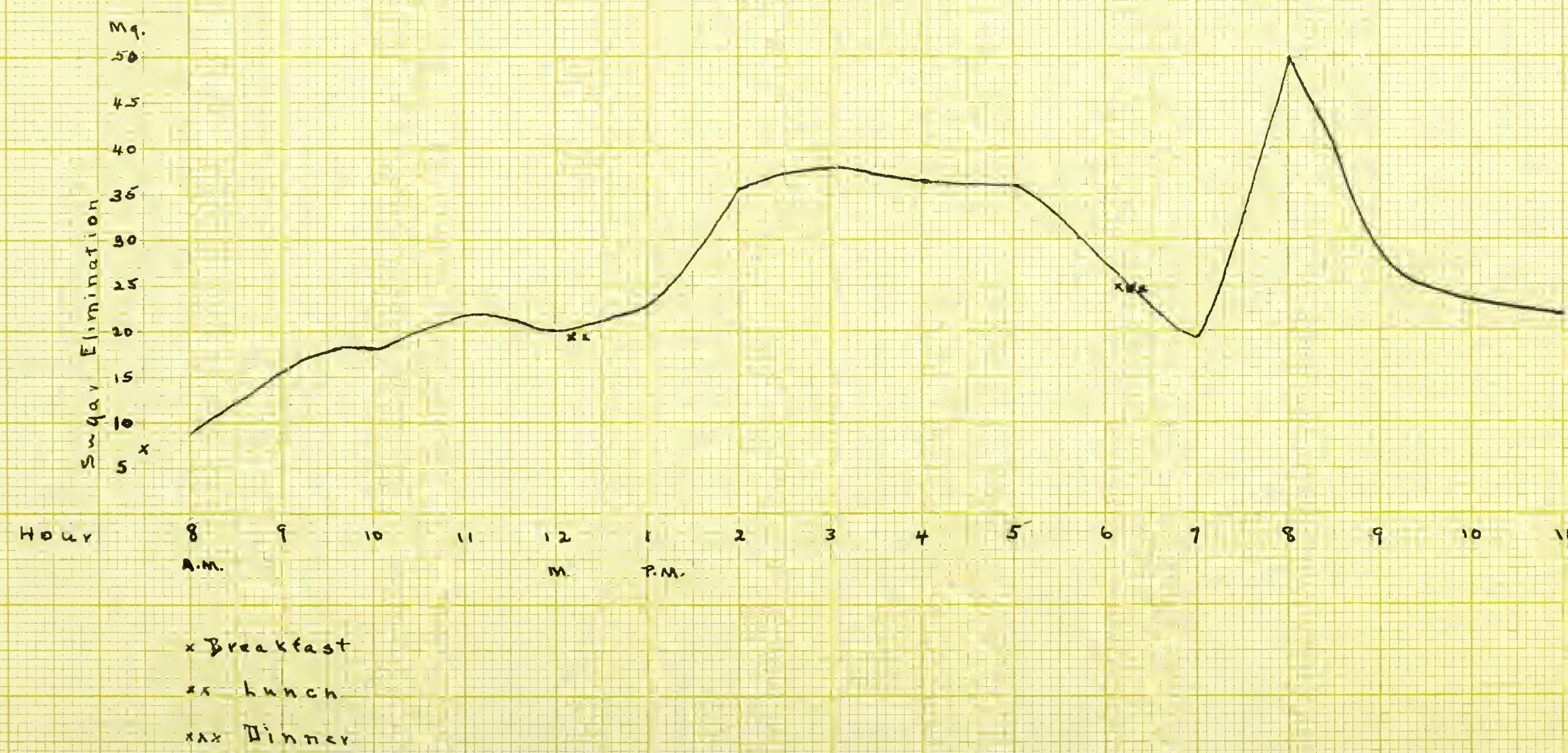
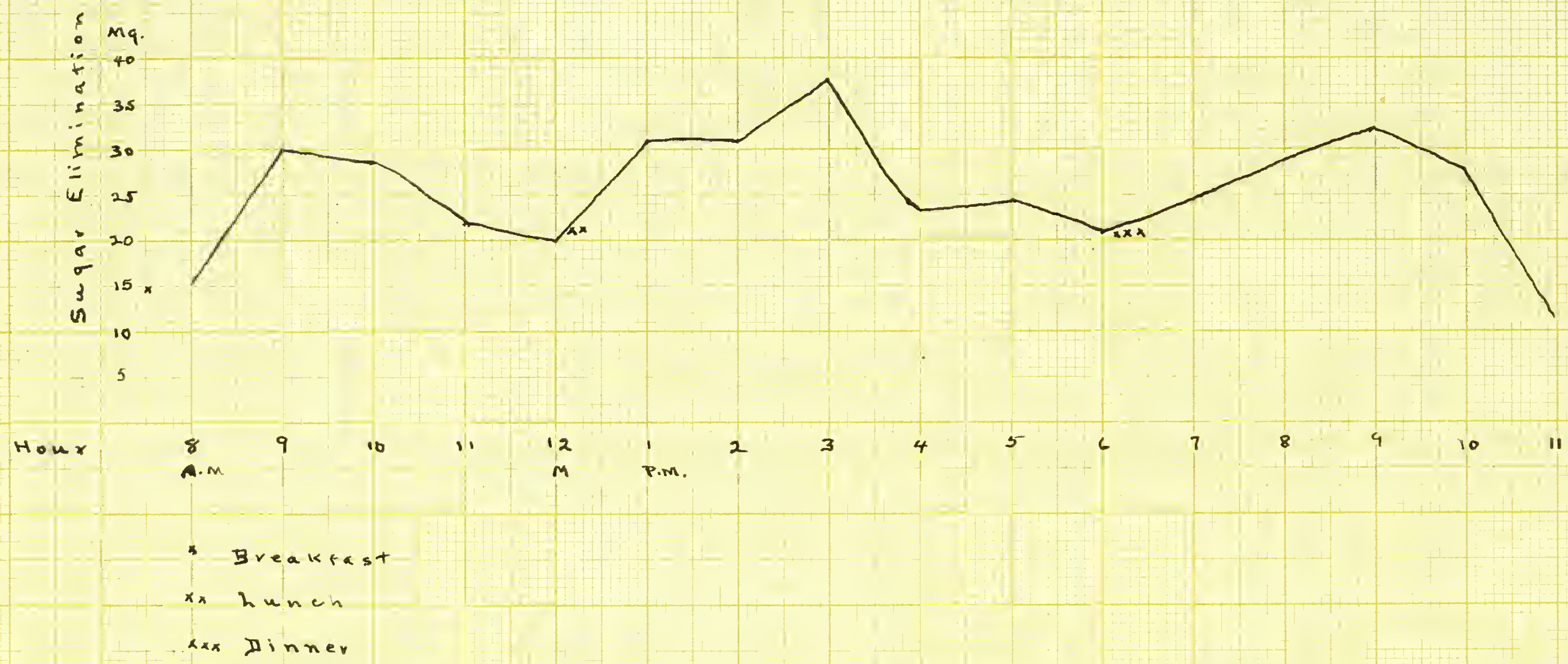


CHART VI

E.A. Hourly Elimination of Sugar on a Carbohydrate-rich Diet



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